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MANAGEMENT OF TECHNICAL DOCUMENTATION IN THE CONTEXT OF GPS STANDARDS CHANGES

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Abstract: *Continuously growing requirements in field of manufacturing machine parts enforce more and more precise (detailed) specification of these requirements. In standards in Geometrical Product Specification (GPS) field (for instance ISO 1101, ISO 14405) many additional tools appeared, especially new, so-called modifiers. Basic technique for verification of workpieces geometry is coordinate measuring technique (CMT). New GPS tools take into account essence of coordinate measurement and also possibilities of CMT and therefore this tools allow to specify many elements of measurement strategy. Important problem appears at management of technical documentation level– previously made drawings (or CAD models) should be continuously modified. In particular, it is necessary to complete documentation with strategy of measurements for most important elements.*
Key words: *Geometrical product specifications, coordinate measuring technique, technical drawing*

1. INTRODUCTION

Continuously growing requirements in field of accuracy (decreasing tolerances) cause situations that in a supplier-customer relation problems related to a significant differences in results of measurements appear. If the parties suspect, that these differences may be result of different measuring strategies, then they are trying to initiate more detailed arrangements. Following to needs of industry new international standards or new editions of standards appear, which provide tools for unified and understandable for all engineers way of specifying requirements in a field of geometrical accuracy of products.

One significant problem is: how to introduce and how to supervise refilling and making changes in technical documentation. There is also another problem: how to teach this subject to engineers during their study – the subject matter is known as a geometrical product specifications (GPS) or widely “geometrical product specification and verification” and it is becoming now independent field of knowledge, which requires serious theoretical basis.

2. DEFINING MEASURING STRATEGY

The problem of comparability of measurement results is connected with measurement uncertainty evaluation. In case the strategy cannot be agreed it’s influence is introduced to the uncertainty. The measurement uncertainty issue including reference to GPS consistency is studied by the Laboratory of Metrology team at University of Bielsko-Biala [1-7].

During calibrations and carrying out trainings in industry, author have an opportunity to observe different ideas for “clarifying” requirements for measuring strategy. In the most cases these are arrangements in the field of probing strategy that is number and distribution of probing points, rarely type of associated element and/or criterion of association.

Figure 1 depicts an example of measurement strategy documentation for hole. It includes: coordinates of axes of holes (defined as theoretically exact dimensions) indications of two diameters and tolerances of axis positions. In addition, type of integral element (circle), probing strategies (for both holes, 4 points in specified distances from facing surface of a workpiece) and diameter of stylus tip (2 mm) have been specified.

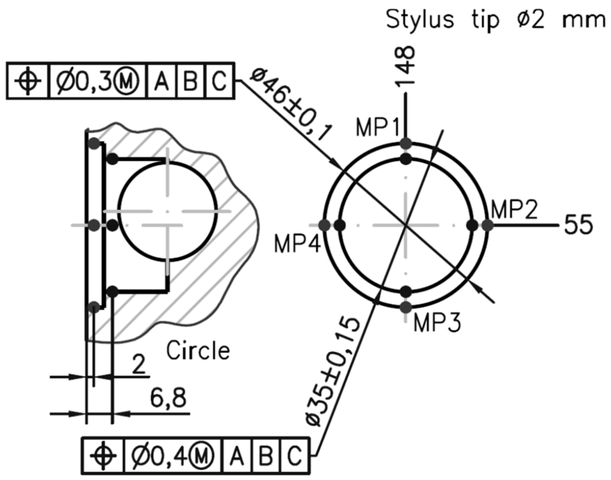

Fig. 1. Cross-section of holes with measuring strategy

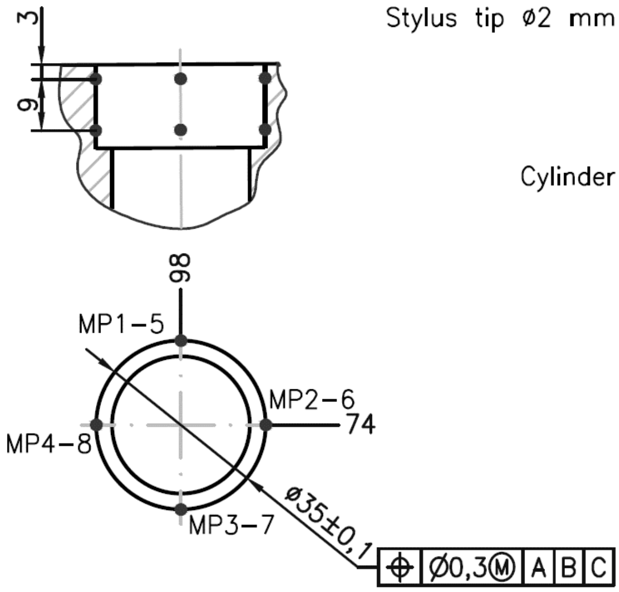

Fig. 2. Example of measurement strategy specification

In Figure 2 section of holes is shown with specification of coordinates of axis of hole (defined as theoretically exact dimensions), indication of diameter and tolerance of axis position. In addition, type of integral element (cylinder), probing strategy (4 points each for two sections, in specified distances from facing surface of a workpiece) and diameter of stylus tip (2 mm) have been specified.

Another example (Figure 3) applies to designation of projected tolerance zone of threaded hole. In this figure coordinates of axis of hole (defined as theoretically exact dimensions), indication of nominal diameter and tolerance of position of thread axis are specified. In addition, it was specified that axis of hole should be measured as an axis of maximum inscribed cylinder on the crests of thread. Probing is performed with use a stylus tip with given diameter (2 mm) and in 8 probing points distributed taking into account thread pitch, it provides similarity of contact probing tip with surface of thread at all probing points.

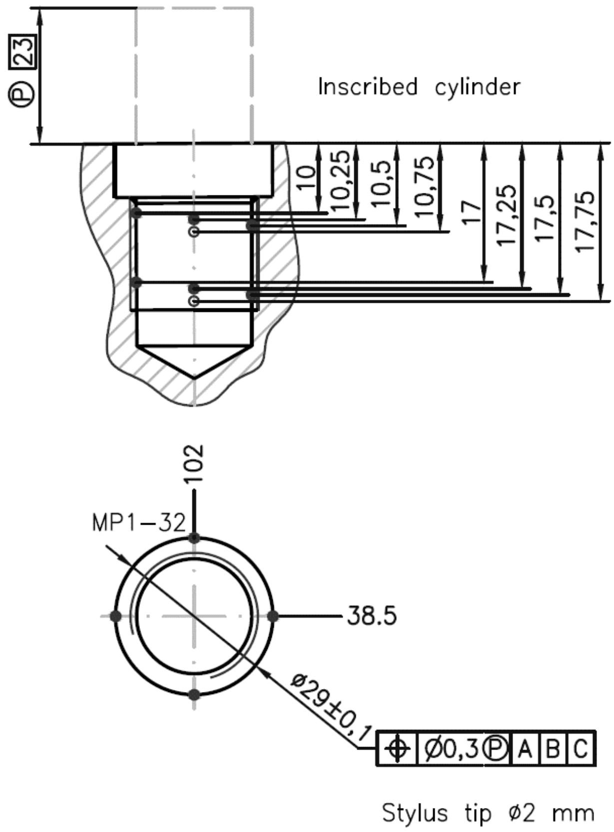

Fig. 3. Example of strategy specification for threaded hole

Commonly used probing strategy of thread, to identify its axis is using stylus with large diameter of stylus tip, probing in large number of points along four generatrices and using maximum inscribed cylinder for a hole or minimum circumscribed cylinder for a shaft as a criterion of association. Application of measuring strategy based on probing of lateral surfaces of thread in self-centering measurement mode, using appropriate tip diameter is very rare.

In Figure 4 measuring strategy to define coordinate system for cylinder block is shown. This coordinate system is also a datum system X, Y, Z, with reference to which positions of many other elements are defined. Plane X defined by three datum target points X1, X2 and

X3 is a primary datum. Secondary datum is a plane of symmetry of first and fourth cylinders holes determined on basis of straight line containing symmetry points of pairs of points Y1 and Y2 as well as Y3 and Y4. Plane defined by symmetry point of points Z1 and Z2 is a tertiary datum.

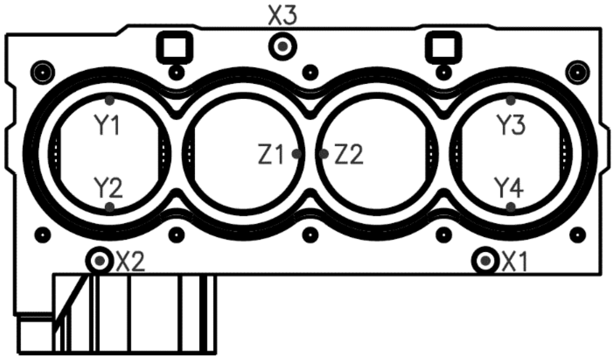

Fig. 4. Simplified drawing of cylinder block cast with measuring strategy elements

Above examples show for need to use a new tools provided by geometrical product specifications. With reference to examples shown in Figures 1 and 2 it is possible to specify defined cross-sections, in which probing should be done, using SCS modifier and theoretically exact dimensions (Figure 5).

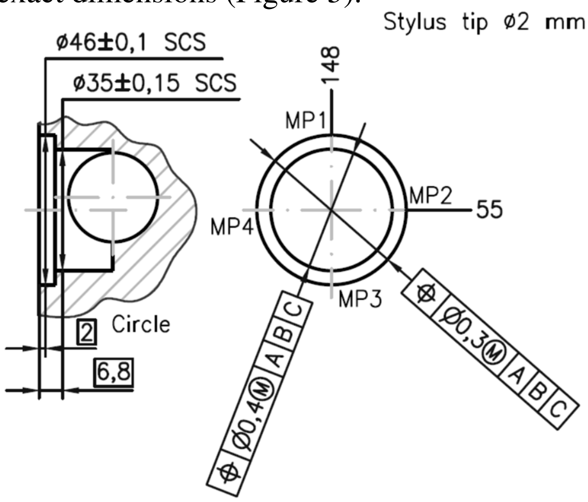

Fig. 5: Example of using SCS modifier unambiguously define cross-section for probing

Figure 4 shown an example of application of "datum targets" of a "point" type and theoretically exact dimensions (TED), which can be used to determine probing locations for datum's.

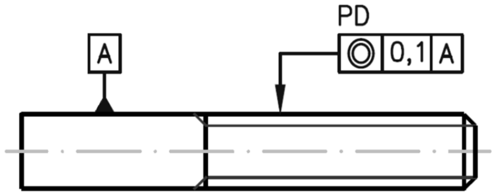

Fig. 6: Control pin for measuring position of threaded hole axis

Determination of strategy of measuring/probing of thread is particularly difficult. Absolutely correct way of measurement (perfect verification operator) requires to use additional element of measuring equipment – accurate gauge pin with 2 coaxial parts - cylindrical and threaded (Figure 6). Application of such solution increases effort and makes automation of measurement impossible.

For all above discussed examples there is no standardised way to determine type of integral feature, association criterion and probing strategy (number and distribution of probing points and/or diameter of stylus tip).

Determining of measuring strategy is especially important with reference to datums. If primary datum is a plane, and datum targets are not indicated, then using large number of well distributed probing points is required with applying „tangential feature" criterion. Primary datum in form of plane is often difficult to access for probing. Theoretically correct technique is to place datum plane of measured part on a flat plate of fixture or just on CMM table and probing (instead of datum surface) the plate/table around a workpiece. Due to usually small flatness of such surfaces it is not necessary to take large number of probing points. However in practice this technique will fail, if datum surface will be convex.

In case of datum system consisting of three mutually perpendicular planes secondary and tertiary planes should be determined in the same manner as primary datum (large number of probing points, tangential feature) with additional fitting constrain of perpendicularity to higher order datums. Experience of authors shows that not all of CMM software provide such possibility, furthermore many of CMM operators do not use this possibility even if software provides this option (Figure 7).

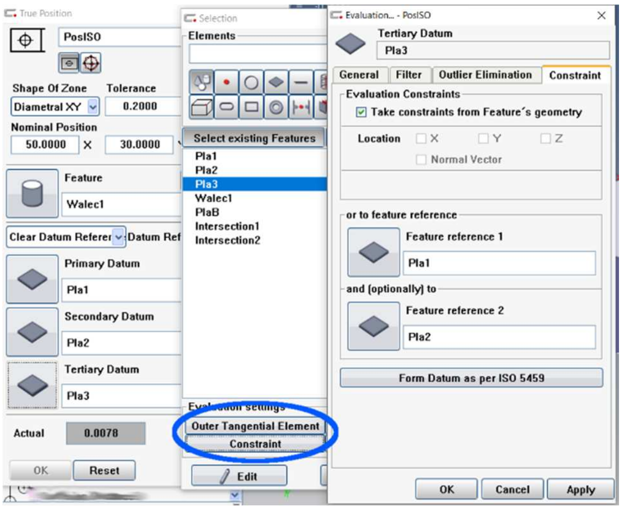

Fig. 7: Dialogue window with perpendicularity condition

In relation to secondary datum theoretically correct technique (perfect verification operator) is also using a fixture and probing its surface, but this technique also fails in case of convex surface (Figure 8).

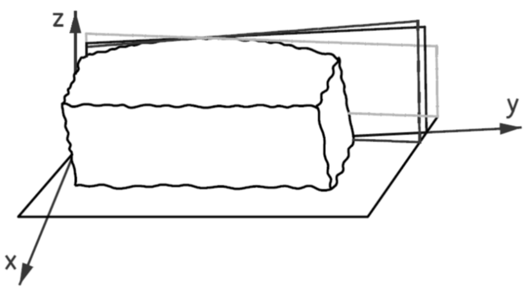

Fig. 8: Problem with ambiguity caused by convex of surface representing secondary datum

In case the datum system consists of three planes simplified verification operators are often used – plane which represents secondary datum in measurement is replaced by straight line, and plane which is a tertiary datum is replaced by point.

Another element, which can cause problems with comparability of measurement results, are procedures of determining of datum systems. In Figure 9 three example methods are shown for establishing a coordinate system consisting of three datum planes.

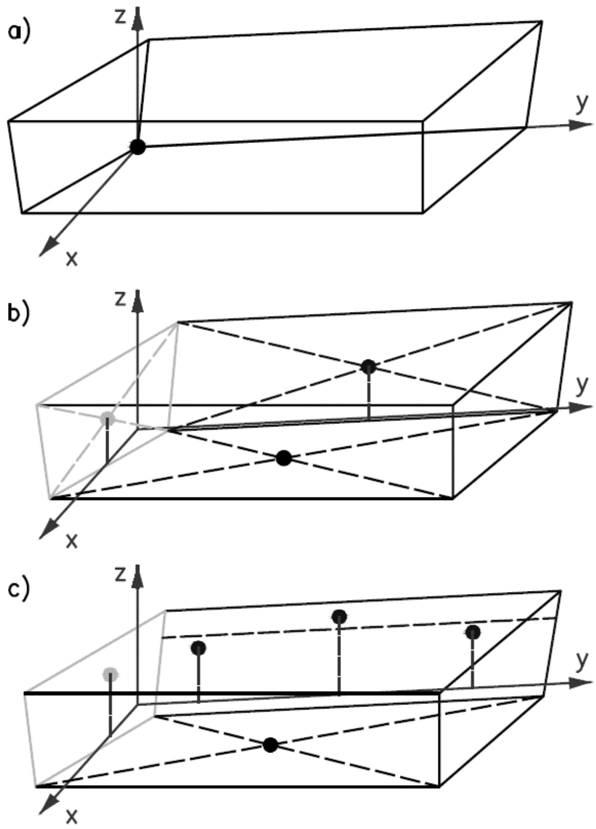

Fig. 9: Coordinate system established basing on datum system: a) coordinate system consists of plane as primary datum, straight line which is intersection line two planes and point of intersection all of three planes, b) coordinate system established by using information about definition points and vectors of the planes, c) simplified verification operator: planes which are secondary and tertiary datums are replaced by, respectively, straight line and point

To obtain comparability of measuring results performed by different operators and often by different CMMs the measuring strategy must be agreed. This problem was noticed in the ISO 17450-2 standard. In the standard, term "ambiguity of specification" appears. This term refers to a case in which incomplete specification operator is applied [14].

2.1. Available tools for detailed geometrical product specification

Modifiers which enable to distinguish different types of sizes [12] appeared as one of the first tools. In addition to previously known default definition of size as two-point local size (independence principle) and Taylor principle [11], according to which toleranced dimension is defined as limited on one side by two-point local sizes and the other by size of tangent feature, the standard gives modifiers which allow to specify different types of local and global sizes. Two-point local size, if necessary, can be marked by LP modifier. Second rare case of local size is local size as a spherical size (LS modifier). The other two local sizes: section size and portion size are marked by indication for which section (SCS modifier) or portion of workpiece (“A ↔ B” modifier) are to be applied (Figure 10).

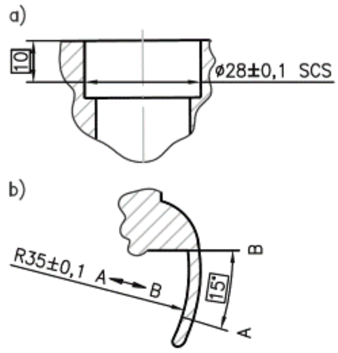

Fig. 10: Example of specification of local sizes: a) section size, b) portion size

These two local sizes and all of global sizes may differ due to association criterion used in measurement. Particular association criterions are marked by modifiers: GG – for least square size, GX – for maximum inscribed size, GN – for minimum circumscribed size and GC — for minimax size (Tchebyshew criterion). Standard defines modifiers for 3 different types of calculated sizes: CC — for circumference diameter (size calculated from circumference), CA — for area diameter (size calculated from area) and CV — for volume diameter (size calculated from volume). Because one workpiece has many local sizes the standard also gives modifiers which enable to specify of requirements for calculated statistics of these sizes, which are called rank-order sizes. These are: SX — for maximum size, SN — for minimum size, SA — for average size, SM — for median size, SD — for mid-range size, SR — for range size and SQ — for standard deviation of sizes. Term “rank-order sizes” is historical, because originally it was intended to define only rank order of sizes. Specifying of type of size can be found in drawings of rolling bearings and in the standard for gauges [10].

ISO 14405-2 standard gives recommendation concerning to avoid of ambiguity by replacing toleranced dimensions with theoretical exact dimensions and tolerances of position (or profile any line/surface) [13]. Many other tools which allow for more unambiguous geometrical product specification can be found in [8, 9, 11].

2.2. Need for documentation of measurement strategy

Typical product development cycle includes:

- design (contains, among others tolerance of sizes and geometrical tolerances),
- making prototypes for testing,
- verification of geometry (designed measuring strategy contains simplifications, so it may not be fully according with specification) – in this case, verification operator which was used should be documented,
- performance tests (e.g. endurance tests),
- possible corrections of tolerances (which refer to previously used verification operator, therefore operator should not be change, even if technical documentation is not compatible with this operator) – this is optimal stage to change specification operator to be compatible with verification operator,
- manufacturing,
- verification according to previously designed measuring strategy (developed verification operator).

Information on measurement strategy applied on different stages is very important for the analysis of results. To ensure correct results and their reliability it is necessary to use tools given in GPS standards. Protect your paper and especially your disk from damages during mail.

3. CONCLUSIONS

Geometrical product specifications tools are continuously growing up – new standards or new editions of GPS standards appear. Similar issue is with CMMs and their software. Even in the same plant the CMMs of different manufacturers, differing in construction, equipment and controlled by different, more or less advanced software are used. Measuring programs for measuring particular workpieces created by different operators may certainly differ in many details of measuring strategy. Therefore, to reduce impact of measuring strategy on results it is a good and common

practice to agree this strategy between supplier and customer on early stage of collaboration.
Obvious and easy to agree element of measuring strategy is broadly defined probing strategy, which in addition to number and distribution of probing points, includes also type of integral feature (most often this applies to choice between cylinder and circle) and association criterion.

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GESTIONAREA DOCUMENTAȚIEI TEHNICE ÎN CONTEXTUL SCHIMBĂRILOR DE STANDARDE GPS

Rezumat: Cerințele în continuă creștere în domeniul prelucrării pieselor de mașină impun o specificare mai precisă (detaliată) a acestor cerințe. În standardele din câmpul Geometrical Product Specification (GPS) (de exemplu, ISO 1101, ISO 14405) au apărut multe instrumente suplimentare, în special noi, așa-numitele modificatoare. Tehnica de bază pentru verificarea geometriei pieselor de prelucrat este tehnica de măsurare a coordonatelor (CMT). Noile instrumente GPS iau în considerare esența măsurării coordonatelor și posibilitățile CMT și, prin urmare, aceste instrumente permit specificarea multor elemente ale strategiei de măsurare. Problema importantă apare la gestionarea nivelului documentației tehnice - desenele făcute anterior (sau modelele CAD) trebuie modificate în mod continuu. În special, este necesară completarea documentației cu strategia măsurătorilor pentru cele mai importante elemente.

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